



Experiments Program for NASA's Space Communications Testbed

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Abstract

NASA developed a testbed for communications and navigation that was launched to the International Space Station in 2012. The testbed promotes new software defined radio (SDR) technologies and addresses associated operational concepts for space-based SDRs, enabled by this first flight of NASA's Space Telecommunications Radio System (STRS) architecture standard. The experiments program consists of a mix of in-house and external experiments from partners in industry, academia, and government. The experiments will investigate key challenges in communications, networking, and global positioning system navigation both on the ground and on orbit. This presentation will discuss some of the key opportunities and challenges for the testbed experiments program.

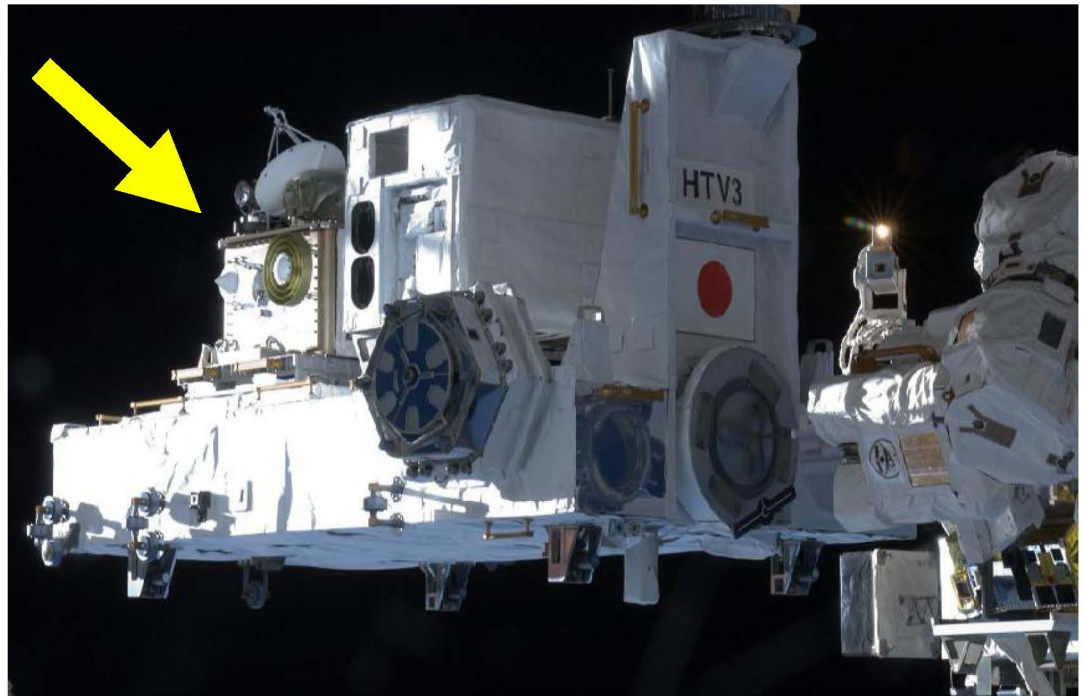


SCAN Testbed ISS Payload

- Space Communications and Navigation (SCAN) Testbed payload
- Formerly the Communications, Navigation, and Networking Reconfigurable Testbed (CoNNeCT)



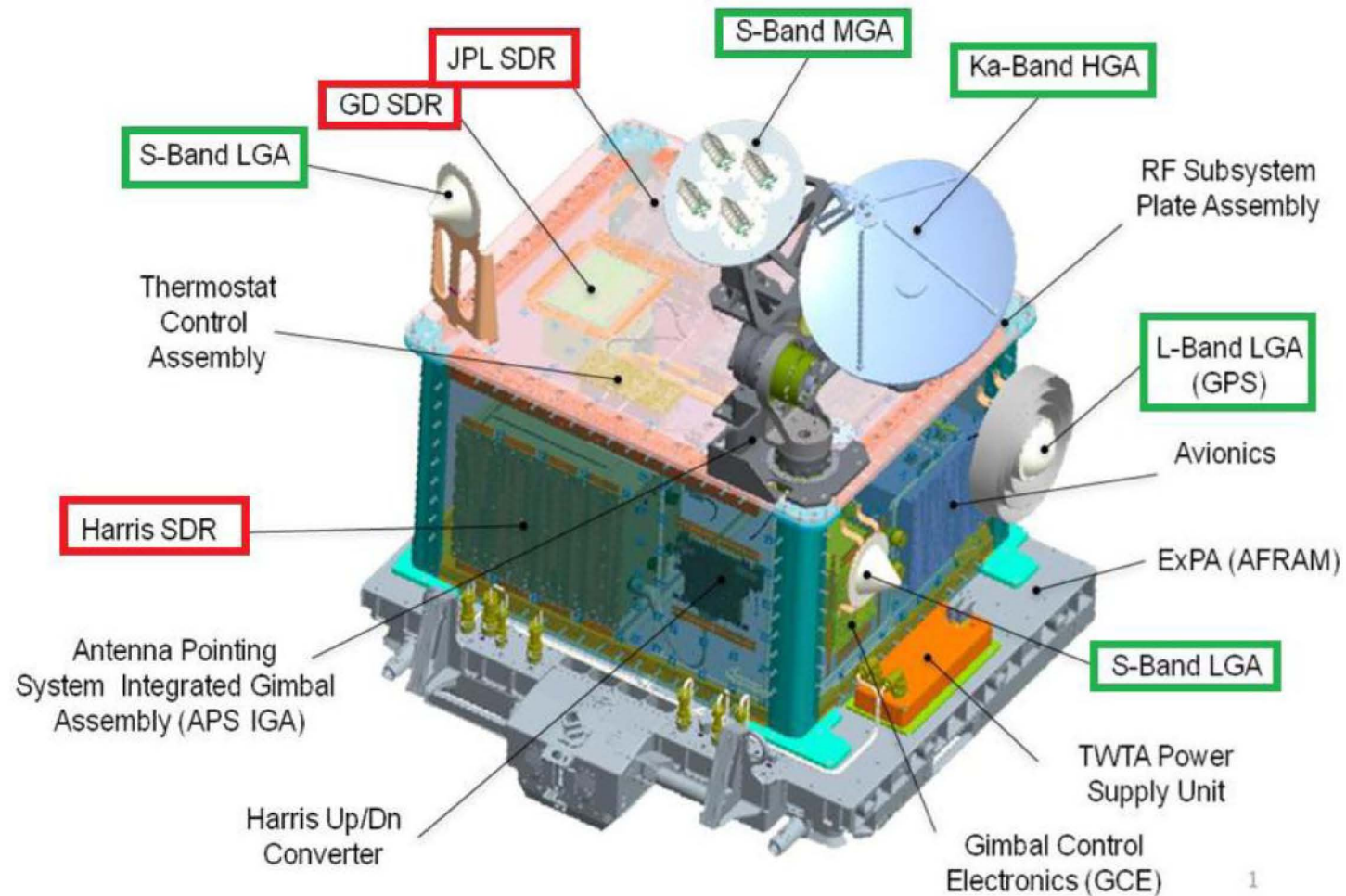
**Launched aboard HTV3 from
Tanegashima Space Center
July 20, 2012 (EDT)**



**Installed to ISS ExPRESS Logistics Carrier 3
August 7, 2012 (EDT)**



SCAN Testbed Components

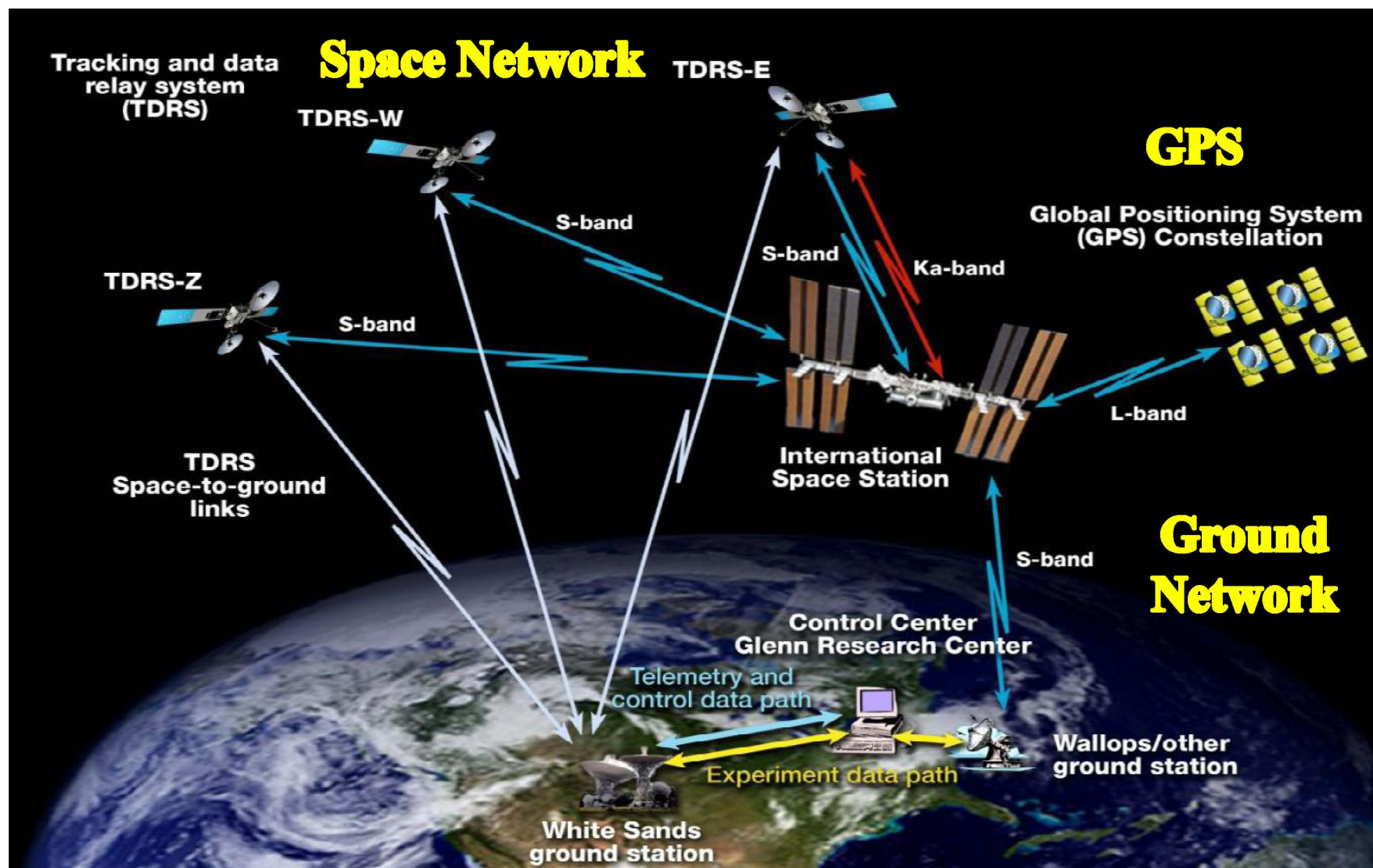


Software Defined Radios

Antennas



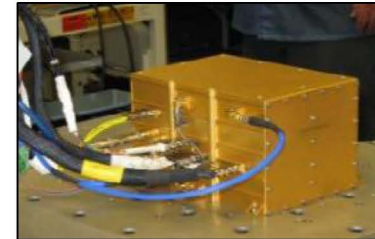
SCAN Testbed Experiment Communication





Software Defined Radios

- General Dynamics (GD) SDR
 - 60 MIPS Coldfire (VxWorks) and (1) QPRO FPGA
 - S-Band transceiver (2.0 – 2.3 GHz) with 8W amp
 - 1M chalcogenide non-volatile phase-change memory.
- Jet Propulsion Laboratory (JPL) SDR
 - 66 MHz SPARC (RTEMS) and (2) Virtex2 FPGAs
 - S-Band transceiver (2.0 – 2.3 GHz) with 7W amp
 - L-Band receiver at L1, L2c, and L5 GPS frequencies
- Harris Corporation SDR
 - 1000 MIPS PowerPC (VxWorks) and (4) Virtex4 FPGAs
 - Ka-Band transceiver (22 – 26 GHz) with 40W TWTA
 - DSP for enhanced signal processing.



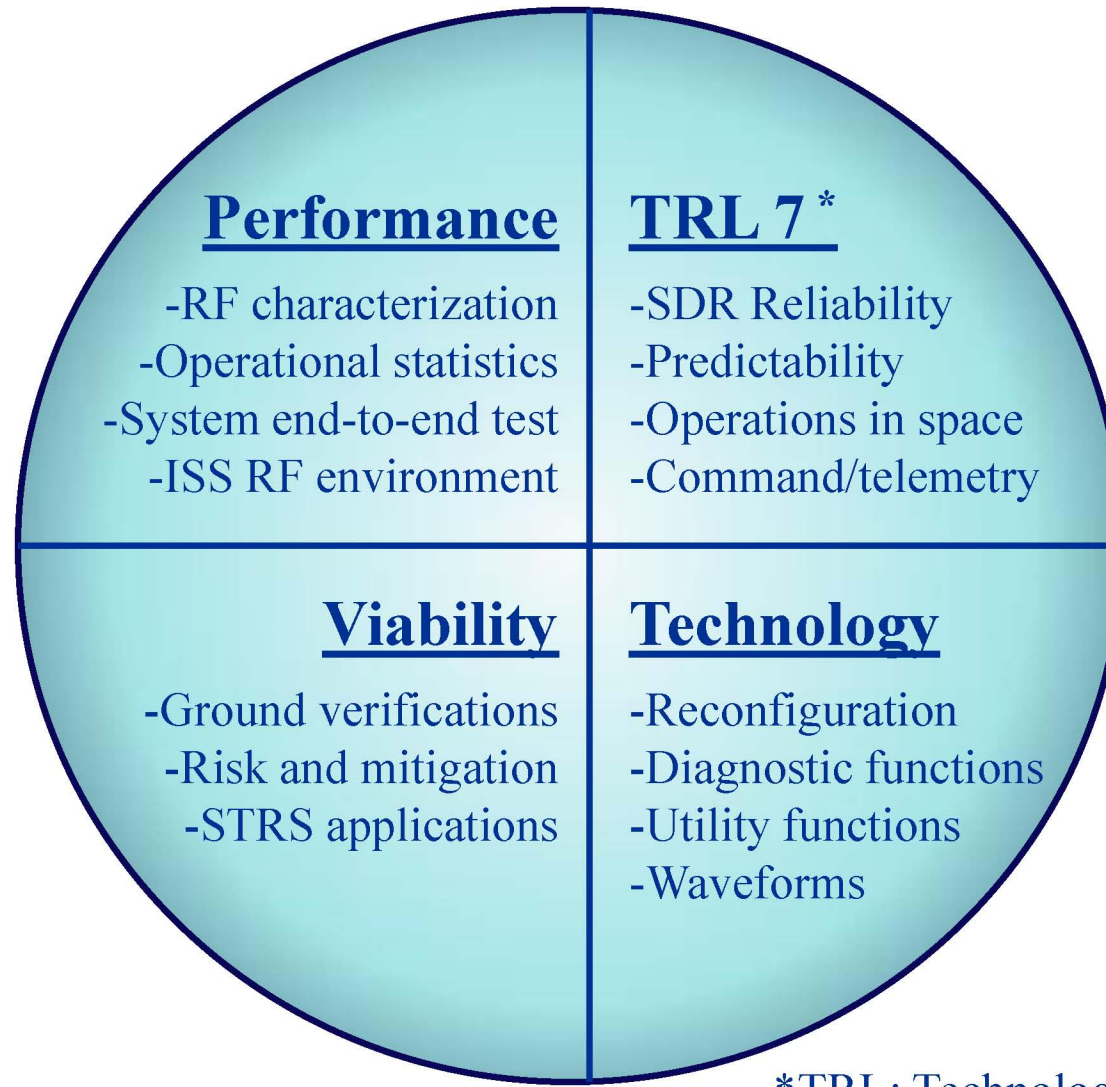


Experiments Program Primary Objectives

- Investigate the application of SDRs to NASA missions
 - Waveform as a commodity, delivered separate from the hardware
 - Reconfiguration (e.g. OE, waveform updates)
 - Waveform software implementation (e.g., modulation, coding, framing)
 - Intensive functions within the radio subsystem (e.g., processing, control)
- Develop SDR technology advancement to TRL-7
 - Promote Agency-wide adoption of NASA's STRS standard
 - Isolate platform, waveform, and environmental effects
- Validate future mission operational capabilities
 - Demonstrate comm., networking, navigation capabilities for future missions
 - Understand SDR performance (reliability, telemetry, instrumentation)
 - Maintain simultaneous RF Links (Ka-band, S-band, L-band/GPS)
 - Load/run/reconfigure experimenter applications from flight computer



SDR Technology Advancement



*TRL: Technology Readiness Level



Technology Advancement Objectives

- Measure the on-orbit performance of the SDRs
 - Compare performance with the baseline ground dataset
 - Use the as-launched waveforms (initially)
 - Exercise the available NASA TDRSS services
- Verify the on-orbit reconfiguration capability of the SDR
 - Establish feasibility for waveform upload and reconfiguration
 - Reconfiguration over experimental path
- Develop applications for assessing SDR performance in space
 - Improve the as-launched waveforms for enhanced capabilities
 - Create new waveforms/utilities to demonstrate viability of space SDRs.
- Periodically assess and report performance statistics
 - Reconfigurations, fault mitigation, single event upsets (SEUs)
 - Operational statistics including hours, RF changes



Space SDR Challenges and Opportunities

- Understand the risks of reconfiguration
 - Expensive payloads need reliable radios for command/telemetry
 - What are the design vulnerabilities of SDRs?
 - Provide redundancy and reduce cost/mass through reconfiguration
- Reduce the level of flight software verification
 - Perform verification of flight code on similar ground hardware
 - Graceful recovery from crashes and software bugs
 - Consider thermal/electrical, FLASH memory, spectral mask limits
- Apply SDR technology in space
 - Flexible FPGAs are subject to Single Event Upsets (SEUs)
 - Keep flight/ground waveforms in sync and up-to-date
 - Extend mission life by adapting to on-board failure/degradation.

SCaN Testbed Experiments Program Reduces Risk



Experiment Ideas

- What we have planned:
 - Technology advancement and evaluation of SDRs in space
 - Networking and routing capabilities + disruption-tolerant
 - GPS processing and analysis in space
 - Bandwidth-efficient waveform development
- Some other possibilities:
 - **Platform Technology:** reconfiguration, integration, space effects
 - **Architectures:** space/ground networks, multiple simultaneous assets
 - **Comm Applications:** adaptive/cognitive, link capacity, network stack
 - **Mission Applicability:** simulate missions for compatibility testing
 - **Position, Navigation, Timing:** L-, S-, and Ka-band integration
 - **RF Sensing:** science applications, dynamic spectrum access



Experiments Opportunity

- Objectives

- Develop a community of experimenters of the on-orbit testbed
 - NASA, industry, academia, government
- Grow the STRS waveform repository; promote software reuse
 - Follow an “open source” model with suitable protection

- Methods

- **Cooperative Agreement Notice**

- Targeted at institutions of higher education (universities)
- NSPIRES (<http://nspires.nasaprs.com>) solicitation NNC12ZRH002C
- Proposals due: Sept 28 2012, Jan 31 2013, or May 31 2013

- **Experiment Opportunity**

- Targeted at commercial, government, and research entities
- Formal announcement is pending
- SCAN Testbed use is coordinated by a Space Act Agreement

